MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2016/2017 SESSION

PTH 0016 – MODERN PHYSICS AND THERMODYNAMICS

(All sections / Groups)

26 MAY 2017
9.00 a.m. – 11.00 a.m.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 5 pages.
2. Answer all questions.
3. Write your answers in the Answer Booklet provided.

QUESTION 1 (15 MARKS)

a) Two lenses, separated by a distance of 22.0 cm are used in combination. The first lens has a focal length of +31.0 cm; the second lens has a focal length of -16.0 cm. The first lens is located to the left of the second lens. An object, 3.00 mm high, is placed 1.9 cm to the left of the first lens.

(i) Calculate the intermediate and final image distances relative to the corresponding lenses.

[5 marks]

(ii) Determine the total magnification.

[2 marks]

(iii) Determine the height of the final image.

[2 marks]

b) Light of wavelength 479 nm is incident on a pair of slits produces an interference pattern on a distant screen. The separation between adjacent bright fringes at the center of the pattern is 0.45 cm. A second light source, when incident on the same pair of slits, produces an interference pattern on the same screen with a separation of 0.56 cm between adjacent bright fringes at the center of the pattern. Calculate the wavelength of the second source.

[4 marks]

c) A glass block with index of refraction 1.7 is submerged in an unidentified liquid. A ray of light inside the block undergoes total internal reflection as shown in **Figure Q1(c)** below. Determine the maximum index of refraction of the unidentified liquid.

[2 marks]

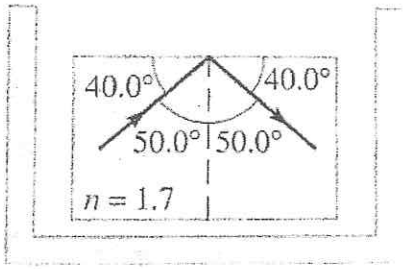

Figure Q1(c)

QUESTION 2 (10 MARKS)

a) Two different monochromatic light sources, one green with wavelength 560 nm, and the other one blue with wavelength 450 nm, are used in a photoelectric effect experiment. The metal surface has a photoelectric threshold frequency of 6.1×10^{14} Hz.

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(i) Are both sources able to eject photoelectrons from the metal? Explain your answer.

[3 marks]

(ii) Determine the amount of energy required to eject an electron from the metal.

[1 mark]

(iii) Calculate the stopping potential when a wavelength of 380 nm is used on the same metal surface.

[2 marks]

b) The energy of the $n = 3$ Bohr orbit is -24.2 eV for an unknown ionized atom, which has only one electron moves around the nucleus.

(i) Calculate the number of protons for the unknown ionized atom.

[2 marks]

(ii) Calculate the radius of the $n = 6$ orbit for this unknown ionized atom.

[2 marks]

QUESTION 3 (10 MARKS)

a) Calculate the mass of a sample of pure ${}^{40}_{19}K$ with an initial decay rate of 2.0×10^5 s^{-1}. The half-life of ${}^{40}_{19}K$ is 1.28×10^9 year.

[4 marks]

b) What is the energy emitted in the following decay process,

(i) ${}^{218}_{84}Po \rightarrow {}^{214}_{82}Pb + {}^{4}_{2}He$

[2 marks]

(ii) ${}^{218}_{84}Po \rightarrow {}^{218}_{85}At + {}^{0}_{-1}e$.

[2 marks]

(Atomic mass values:
${}^{218}_{84}Po = 218.008965u, {}^{214}_{82}Pb = 213.999798u, {}^{4}_{2}He = 4.002602u, {}^{218}_{85}At = 218.00868u$)

c) At $t = 0$, a pure sample of radioactive nuclei contains N_o nuclei whose decay constant is λ. Determine a formula for the number of daughter nuclei, N_D, as a function of time; assume the daughter is stable and that $N_D = 0$ at $t = 0$.

[2 marks]

QUESTION 4 (15 MARKS)

a) The PV diagram in **Figure Q4(a)** shows two possible states of a system containing 1.55 moles of a monatomic ideal gas. ($P_1 = P_2 = 455$ N/m^2, $V_1 = 2.00$ m^3, $V_2 = 8.00$ m^3).

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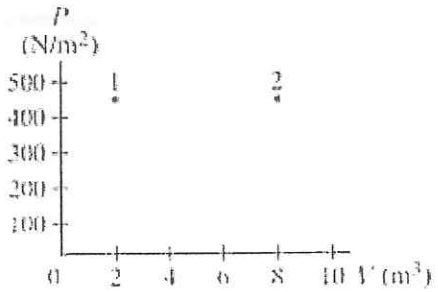

Figure Q4(a)

(i) Sketch the process which depicts an isobaric expansion from state 1 to state 2 and label this as process A.

[1.5 mark]

(ii) Sketch the two step process which depicts an isothermal expansion from state 1 to the volume V_2, followed by an isovolumetric increase in temperature to state 2 and label this as process B.

[2.5 marks]

(iii) Find the work done by the gas and the change in internal energy of the gas in (i) above.

[4 marks]

(iv) Find the change in internal energy of the gas for the two – step process in (ii) above.

[1 mark]

b) The 1.20 kg head of a hammer has a speed of 7.5 m/s just before it strikes a nail as shown in **Figure Q4(b)** and is brought to rest. Estimate the temperature rise of a 14 g iron nail generated by 10 such hammer blows done in quick succession. Assume the nail absorbs all the energy. Given that the heat capacity of nail is 450 J/kg°C.

[3 marks]

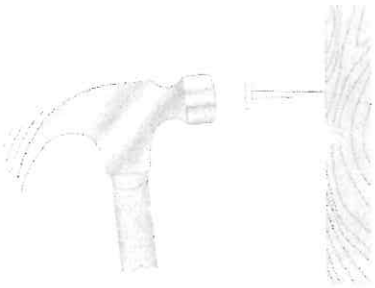

Figure Q4(b)

c) A 30 g ice cube at its melting point is dropped into an insulated container of liquid nitrogen. The heat from ice is then used to evaporate the nitrogen at its boiling point of -196°C which has a latent heat of vaporization of 200 kJ/kg. Calculate the mass of the evaporated nitrogen. Given the specific heat of ice is 2100 J/kg°C.

[3 marks]

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APPENDIX

LIST OF PHYSICAL CONSTANTS

Electron mass,	m_e	=	9.11×10^{-31} kg
Proton mass,	m_p	=	1.67×10^{-27} kg
Neutron mass,	m_n	=	1.67×10^{-27} kg
Magnitude of the electron charge,	e	=	1.60×10^{-19} C
Universal gravitational constant,	G	=	6.67×10^{-11} N m^2 / kg^2
Universal gas constant,	R	=	8.314 J/mol K
Hydrogen ground state,	E_0	=	13.6 eV
Boltzmann's constant,	k_B	=	1.38×10^{-23} J/K
Compton wavelength,	λ_c	=	2.426×10^{-12} m
Planck's constant,	h	=	6.63×10^{-34} J s
		=	4.14×10^{-15} eV s
Speed of light in vacuum,	c	=	3.00×10^8 m/s
Rydberg constant,	R_H	=	1.097×10^7 m^{-1}
Acceleration due to gravity of earth,	g	=	9.80 m/s^2
1unified atomic mass unit,	1 u	=	931.5 MeV/c^2
		=	1.66×10^{-27} kg
1 electron volt,	1 eV	=	1.60×10^{-19} J
Avogadro's number,	N_A	=	6.02×10^{23} mol^{-1}
Threshold of intensity of hearing,	I_0	=	1.0×10^{-12} W/m^2
Coulomb constant,	$k = \frac{1}{4\pi\varepsilon_0}$	=	9.0×10^9 N m^2 /C^2
Permittivity of free space,	ε_0	=	8.85×10^{-12} C^2/N m^2
Permeability of free space,	μ_0	=	$4\pi \times 10^{-7}$ T m/A
1 atmosphere pressure,	1 atm	=	1.013×10^5 N/m^2
		=	1.013×10^5 Pa
Wien's displacement constant		=	2.90×10^{-3} mK
Speed of sound in air		=	343 m/s
Refractive index of air/vacuum	n	=	1.0
Earth: Mass,	M_E	=	5.97×10^{24} kg
Radius (mean),	R_E	=	6.38×10^3 km
Moon: Mass,	M_M	=	7.35×10^{22} kg
Radius (mean),	R_M	=	1.74×10^3 km
Sun: Mass,	M_S	=	1.99×10^{30} kg
Radius (mean),	R_S	=	6.96×10^5 km
Earth-Sun distance (mean),		=	149.6×10^6 km
Earth-Moon distance (mean),		=	384×10^3 km
First Bohr Raduis,	a_o	=	0.053 nm

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LIST OF FORMULAS

$$\sin\theta_1 + \sin\theta_2 = 2\sin\left(\frac{\theta_1+\theta_2}{2}\right)\cos\left(\frac{\theta_1-\theta_2}{2}\right)$$

$$\cos\theta_1 + \cos\theta_2 = 2\cos\left(\frac{\theta_1+\theta_2}{2}\right)\cos\left(\frac{\theta_1-\theta_2}{2}\right)$$

$$\sin\left(\theta+\frac{\pi}{2}\right) = \cos\theta$$

$\sin\theta \approx \tan\theta \approx \theta$ *rad* for small angles

$D(x, t) = D_M \sin(kx \pm \omega t \pm \phi)$

$$v = \sqrt{\frac{F_T}{\mu}} \qquad v = \sqrt{\frac{\text{elastic property of the medium}}{\text{inertia property of the medium}}} \qquad v = (331 + 0.60T) \qquad v = f\lambda$$

$$f_n = \frac{nv}{2L} \qquad f_n = \frac{nv}{4L} \qquad \lambda_n = \frac{2}{n}L \qquad f' = f\left(\frac{v \pm v_o}{v \mp v_s}\right)$$

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \qquad \frac{1}{f} = (n-1)\left\{\frac{1}{R_1} + \frac{1}{R_2}\right\} \qquad f = \frac{R}{2}$$

$$d\sin\theta = m\lambda \qquad d\sin(\theta) = \left(m+\frac{1}{2}\right)\lambda \qquad a\sin(\theta) = n\lambda$$

$$\lambda_m . T = 0.2898 \times 10^{-2} \qquad I(\lambda, T) = \frac{2\pi c k_B T}{\lambda^4}$$

$$E_n = -\frac{mk^2e^4}{2\hbar^2}\left(\frac{1}{n^2}\right) \qquad r_n = \frac{\hbar^2}{mke^2}n^2 \qquad L = mvr_n = n\hbar$$

$$\frac{1}{\lambda} = R_H\left[\frac{1}{n_i^2} - \frac{1}{n_f^2}\right] \qquad \frac{1}{\lambda} = \frac{mk^2 Z^2 e^4}{4\pi c\hbar^3}\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right] \qquad \lambda = \frac{h}{p}$$

$$R = R_0 e^{-\lambda t} \qquad \lambda = \frac{\ln 2}{T_{1/2}} \qquad Q = (M_X - M_Y - M_\alpha)\,c^2$$

$$pV = nRT \qquad k = \frac{R}{N_A} \qquad N = N_0 e^{-\lambda t}$$

$$\frac{\Delta Q}{\Delta t} = -kA\frac{\Delta T}{\Delta L} \qquad \frac{\Delta Q}{\Delta t} = e\sigma AT^4 \qquad \frac{\Delta Q}{\Delta t} = IeA\cos(\theta)$$

$$\overline{KE} = \frac{1}{2}m\bar{v}^2 = \frac{3}{2}kT \qquad U = \frac{3}{2}nRT$$

$$Q = \Delta U + W \qquad W = \int dW = \int_{V_i}^{V_f} P\,dV \qquad W = P\Delta V$$

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